LEARN ONE THING EVERY DAY

OCTOBER 15 1919 SERIAL NO. 189

THE MENTOR

THE STORY OF OIL

By C. F. TALMAN
Editorial Writer, Scientific American

DEPARTMENT OF SCIENCE

VOLUME 7
NUMBER 17

TWENTY CENTS A COPY

LIGHT OUT OF DARKNESS

FIFTY years ago more than half the world lived in darkness for want of a suitable light. Coal gas for illuminating purposes had come into more or less general use in the cities and some of the larger towns, and burning oils for lamps had been successfully manufactured from coal and shale rocks in several European countries, as well as in the United States. But the great mass of the country folk of the world were still restricted to the use of dim candles, or vile-smelling, spluttering lamps which burned animal or vegetable oils. Hordes of people in India, China and Russia were trying pitifully to make light with tallow fats in open cups, and rude wicks fashioned from plant fiber. Little wonder it is that, in the days of our grandfathers, "early to bed" was the rule, for there was no pleasure to be found in spending an evening with only the fitful flickering of a candle to light the dreary hours.

* * *

Now all is changed. Night is turned into day by the powerful gas and electric lamps of the great city, where the stream of life never ceases throughout the twenty-four hours. Great, indeed, is the service which these lights perform for the complex life of the modern metropolis. But greater still is the service that has been done by the humble kerosene or paraffin oil lamp in the quiet homes of the plain people who bear the brunt of the world's work. It has carried the light of civilization into every corner of the earth. It has literally made life longer for the millions, by turning hours of darkness into hours of profitable pleasure and enjoyment. Common as it is, the ordinary kerosene lamp is one of the greatest inventions of the world in its service and benefits to mankind. Yet kerosene is only one of a hundred necessities of everyday life that come from the world-wide deposits of petroleum.

From "Petroleum, the Motive Power of the Future," by W. S. Tower and John Roberts.

THE MENTOR ASSOCIATION

ESTABLISHED FOR THE DEVELOPMENT OF A POPULAR INTEREST IN ART, LITERATURE, MUSIC, SCIENCE, HISTORY, NATURE AND TRAVEL

THE MENTOR IS PUBLISHED TWICE A MONTH

BY THE MENTOR ASSOCIATION, INC., AT 114-116 EAST 16TH STREET, NEW YORK, N. Y. SUBSCRIPTION: FOUR DOLLARS A YEAR. FOREIGN POSTAGE 75 CENTS EXTRA. CANADIAN POSTAGE 50 CENTS EXTRA. SINGLE COPIES TWENTY CENTS. PRESIDENT, THOMAS H. BECK; VICE-PRESIDENT, WALTER P. TEN EYCK; SECRETARY, W. D. MOFFAT; TREASURER, J. S. CAMPBELL; ASSISTANT TREASURER AND ASSISTANT SECRETARY, H. A. CROWE.

OCTOBER 15, 1919 VOLUME 7 NUMBER 17

Entered as second-class matter March 10, 1913, at the postoffice at New York, N. Y., under the act of March 3, 1879.

THE STORY OF OIL

By CHARLES FITZHUGH TALMAN
Editorial Writer for The Scientific American

Courtesy Oil Well Supply Co Pittsburgh
THE FIRST OIL WELL
Drilled by E. L. Drake in 1859 near Titusville, Pa.

MENTOR GRAVURES

DRILLING FOR OIL IN OKLAHOMA

MODEL OF A PETROLEUM REFINERY

DRILLING AN OIL WELL BY THE ROTARY PROCESS

A FIFTY-FIVE THOUSAND-BARREL OIL TANK ON FIRE

GAS WELL, "BLOWING WILD"

DIGGING ASPHALT, TRINIDAD

HUNDREDS of valuable oils, such as linseed oil and cottonseed oil, lard oil and whale oil, are obtained from the vegetable and animal kingdoms; but these are all overshadowed in importance by the mineral oil, drawn from the depths of the earth, that we call *petroleum*. Though now classed as a mineral, petroleum, like coal, is probably a product of bygone living matter. Its mode of origin is not so well understood as that of coal. We do not know what kinds of animals or plants yielded it, nor how it was produced. One point, however, is clear,—its formation was a very slow process. Nature spent long ages in storing it in the ground, *and man is using it up with reckless speed.*

Every day the world is becoming more dependent upon petroleum as a source of necessities and luxuries, and every day we are drawing nearer to the time when we shall have to do without it. One of the most urgent industrial problems of the world today is that of *prolonging* the life of this limited resource until substitutes for it have been found in ample quantity and until we have adjusted our habits and our appliances to the use of them.

The United States produces two-thirds of all the petroleum used in the world. It is believed that the production of nearly 350,000,000 barrels*

*A barrel of petroleum=42 gallons.

Entered as second-class matter March 10, 1913, at the postoffice at New York, N. Y., under the act of March 3, 1879.

per annum recently attained represents the "peak" of our output, and that we have now used about forty per cent. of the total amount in the ground. It is also estimated that in a single year (1917) unwise methods of production and use were responsible for a wastage of petroleum in this country to a value of $835,000,000.

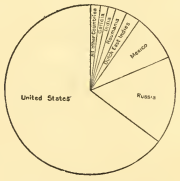
OCCURRENCE OF OIL AND NATURAL GAS IN THE GROUND
Photograph of a Model in the Division of Mineral Technology, U. S. National Museum

Now let us see why this is a matter of vital concern to all of us. Perhaps few people realize the important part that petroleum and its products have come to play in the daily life of humanity and in the great modern industries. We all know that kerosene is made from petroleum. Many persons now living can remember the time when candles were the common means of illumination outside of gas-lighted towns, and lamps were rare because of the poor quality and high cost of the animal and vegetable oils burned in them. The introduction of the kerosene lamp was one of the greatest contributions ever made to the welfare of the human race, and its use has penetrated to every corner of the globe.

Nowadays the most conspicuous product of petroleum is gasoline (called by our British cousins "motor spirit" or "petrol"). Within the past few years the world has acquired millions of automobiles, to say nothing of farm tractors, motor-boats, airplanes and other devices, built in the confident expectation that there would always be plenty of gasoline to run them. It will be no easy task to adapt these machines to use other fuels, or to find other fuels for them to use; but sooner or later this must be done.

More than half the petroleum produced in this country is burned under steam boilers as "fuel oil," either in the crude form or after distillation. It is the common substitute for coal in industrial use throughout the southwestern United States, and it is growing rapidly in favor as a fuel for steamships, especially naval vessels.

Nearly all the machinery in the world is lubricated with oils made from petroleum. At present no satisfactory substitute for these oils is known. More than three-fourths of the manufactured gas of our towns and cities is made from or enriched by petroleum. Products of petroleum are used on a large scale in road building and roofing; as insulating material in electrical work; in inks, dyes and paint bodies; in explosives, turpentine substitutes, soaps, insecticides, medicines, and many other articles of everyday use. Petroleum is the source of vaseline and the principal



DISTRIBUTION OF WORLD'S PRODUCTION OF CRUDE PETROLEUM IN 1916
(U. S. Geological Survey)

source of paraffin. Commercial products of petroleum number more than three hundred, and chemists foresee innumerable additions to the list. With the exception of iron, petroleum is the most useful mineral at the disposal of mankind.

The Oil in the Ground

Petroleum is not a definite chemical compound, but a mixture of numerous compounds of carbon and hydrogen (hydrocarbons), together with small amounts of substances containing sulphur, oxygen and nitrogen. When this oil is slightly heated, certain of its constituents pass off as vapor. At successively higher temperatures, various other ingredients are vaporized, until a solid residue remains. This process of separating the different substances in petroleum by applying different degrees of heat is called *fractional distillation*. The natural distillation of petroleum in the ground has resulted in the production of *natural gas* and of a solid residue in the form either of *paraffin* or of *asphalt*. Crude petroleums found in different parts of the world differ widely in composition, appearance and properties. They are divided roughly into two classes—*paraffin oils*, in which the solid product of distillation is paraffin, and *asphaltic oils*, in which it is asphalt. All the substances above mentioned are known collectively as *bitumens*. The lighter and more volatile liquid bitumens are sometimes classified as *naphthas*, while a heavy, pitch-like liquid bitumen, which occurs widely in Nature, is described as *maltha* or *mineral tar*. Unfortunately there is much confusion in the use of the names applied to the various bitumens, both natural and artificial.

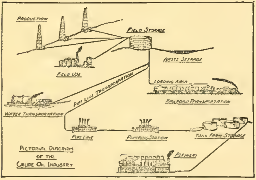


DIAGRAM OF THE CRUDE PETROLEUM INDUSTRY
From Report of the Committee on Petroleum, California State Council of Defense

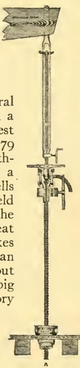
Places where deposits of petroleum occur in the ground are often called "pools," but they are really beds of porous rock, such as sand or sandstone, saturated with oil, and covered with a layer of shale or other impervious material. These porous rocks ("oil sands") sometimes hold as much as one-fifth of their bulk of petroleum. The oil is often found associated with water (mostly brine) and with natural gas. When these three substances occur in

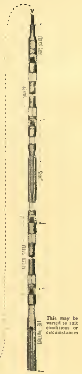
arched or dome-shaped strata, the gas collects at the top, the water at the bottom, and the petroleum in the middle, as shown in the illustration on page 2.

Drilling for Oil

The modern oil well is sunk by one of several methods of drilling, and its depth varies from a few score to a few thousand feet. The deepest well in the world was sunk to a depth of 7,579 feet, near Fairmont, W.Va., and abandoned without striking oil. Drilling for oil is always a lottery. Even in the midst of producing wells a new one may prove a "duster" (*i.e.*, may yield no oil), while in prospecting new territories the seeker for oil must be prepared to put a great deal of money into the ground before he takes any out. One British concern spent more than a million dollars in boring for oil in Persia without any results, but was eventually rewarded by a big "strike." Drilling for oil in untested territory is known as "wildcatting."

When an oil man takes possession of a tract of land for drilling purposes, the first wells are usually sunk near the border of the land, in order to draw as much oil as possible from neighboring property. If the supply of oil underground were inexhaustible, there would be no occasion for this piratical practice, but a "pool" of oil is soon drained, and one must make hay while the sun shines.





Courtesy Oil Well Supply Co.

TEMPER SCREW WITH CABLE ATTACHED

A "STRING" OF DRILLING TOOLS

The most conspicuous part of the drilling outfit consists usually of a tall framework of wood, or sometimes of steel, known as the *derrick*. As this is commonly left in place during the productive life of the well, it is a familiar sight throughout the oil country.

In the United States the great majority of wells are drilled by the so-called *standard* or *cable-tool* method. This employs a walking-beam, driven by an engine, to churn the hole by imparting an up-and-down motion to a heavy "string of tools" suspended from a cable,

Courtesy U. S. Bureau of Mines

CHANGING BITS

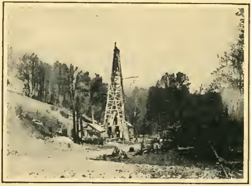
Drilling through rock soon dulls the bit, which must then be removed and replaced by a sharp one

Courtesy U. S. Bureau of Mines
"SHOOTING" AN OIL WELL

which is attached to the end of the beam. After drilling a few feet the tools are withdrawn, and a metal cylinder with a valve at the bottom—the *bailer*, or *sand-pump*—is lowered into the hole to collect and remove the cuttings. At intervals during the drilling sections of iron pipe are forced into the hole, which is thus lined or "cased" to prevent caving and the inflow of water.

A complete string of tools weighs from one to two tons, and terminates in a sharp *bit*, made in various forms for use in penetrating different kinds of material. It is the weight of the falling tools that drills the hole. In pounding its way through the rock the edge of the bit is quickly dulled. Hence it is necessary to draw up the tools and change bits at frequent intervals. The tall derrick provides the means of lifting and lowering the long string of tools, as well as sections of casing, etc. In the middle of the string of tools are the *drilling-jars*. These resemble two great links of a chain, sliding over each other, and are brought into play by slacking up the cable with the *temper-screw*, just below the walking-beam. By giving a smart upward jerk, instead of a steady pull, the jars serve to loosen the bit when it becomes jammed on account of caving or any other cause.

A frequent source of trouble to the driller is the breaking or loss of tools or pieces of casing in the bore hole. As these accidents may occur at a depth of a thousand feet or more in a hole less than a foot in diameter, they present difficult problems to deal with and sometimes put the well permanently out of business; but as a rule the damage can be repaired with the aid of various ingenious *fishing-tools*, which evince almost human intelligence in the versatile feats they accomplish underground.

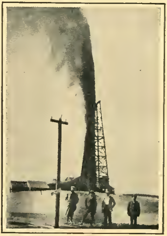


THE DEEPEST WELL IN THE WORLD
Near Fairmont, W. Va. Abandoned June, 1919, on account of broken cable. Depth, 7,579 feet
Drilled by Hope Natural Gas Company

For sinking wells through loose or soft formations, such as prevail in some of the Southern and the California oil fields, the *rotary*, or *hydraulic* method is preferred to the cable-tool method. The hole is bored by a rapidly turning column of pipe, provided with a cutting edge. During the operation

muddy water is pumped down inside the pipe and through an opening in the bottom, whence it returns to the surface on the outside of the pipe, bringing with it the drill cuttings.

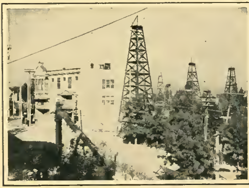
When an oil-bearing bed is tapped, the oil may spout forth with great violence, under the pressure of the confined gas. Such a well is known as a "gusher." A big gusher generally wrecks the derrick and sends up such prodigious volumes of oil that the lucky owner of the well is at his wits' end to take care of it. A well in the Cerro Azul pool, Mexico, is reported to have produced 12,600,000 gallons a day; another in Mexico, known as Potrero del Llano No. 4, is said to have spouted more than 5,000,000 gallons a day; one in the Grozni oil field, in the northern Caucasus, threw up more than 4,500,000 gallons a day during the first three days; while the famous Lakeview gusher, in Kern County, California, yielded 2,500,000 gallons a day at the height of its flow. In such cases vast lakes of oil, confined by hastily improvised earthen walls, accumulate near the well.



THE LAKEVIEW GUSHER, SAN JOAQUIN VALLEY, CAL.

When two months and a half had passed the Lakeview well had produced 3,500,000 barrels of oil and its flow amounted to 60,000 barrels a day

While many wells flow spontaneously when first drilled, sooner or later every well must be pumped. Several wells are often pumped by a single engine, with which they are connected by rods or cables. "Shooting" the well is a common expedient for starting the flow of oil, or for stimulating its flow when it begins to decline. This consists in exploding a large charge of nitroglycerine at the bottom of the well. The yield of an oil well soon reaches its maximum, and then steadily diminishes, the life of a well varying from a few months to twenty or twenty-five years.



Courtesy U. S. Geological Survey

AN OIL TOWN IN CALIFORNIA

From Well to Refinery

In the early days of the petroleum industry oil was generally refined near the points of production, owing to the expense and difficulty of transportation, by wagons, boats and railways. The introduction of *pipe lines*

revolutionized the industry. Crude petroleum is now carried through a system of pipes from the various oil fields to a few large refineries, seaports and markets. Thousands of miles of these pipes spread over a great part of the country, carrying oil all the way from Kansas, Oklahoma and Texas to the Atlantic seaboard, connecting the California fields with the Pacific coast, and linking various fields in the Rocky Mountain region. The pipes run up hill and down dale; scale high mountains and dive under rivers. Pumping stations, equipped with powerful pumps, are located at intervals along the pipe lines to maintain the flow of oil. The pipe-line companies also provide facilities for storing oil, in groups of tanks known as "tank farms." A single farm may contain as many as 400 tanks, with a combined capacity of 10,000,000 barrels of oil. Refined oils are transported to some extent in pipes, but more usually by rail, in *tank cars*. Both crude oil and the bulk products of the refinery are carried by sea in steel tankers and towing barges, fitted with numerous non-communicating compartments. In this country petroleum is stored in steel tanks of certain standard sizes, ranging up to a capacity of 55,000 barrels, or sometimes in immense concrete reservoirs, of which the very largest hold fully a million barrels of oil.

Courtesy U. S. Geological Survey

WELLS ALONG A PROPERTY LINE

Wells of two companies in California, planted close to dividing line of the properties in order to draw oil from each other's land

The first oil pipe line, five miles in length, was laid in Pennsylvania in 1865. This convenient method of transporting petroleum is now in use in oil-producing countries throughout the world, and several of the foreign lines represent remarkable feats of engineering. At Tuxpam, on the coast of Mexico, owing to a lack of harbor facilities, vessels load oil

Courtesy U. S. Geological Survey

DRAWING OIL FROM THE OCEAN BED, SUMMERLAND, CAL.

from submarine pipes extending a mile out from the shore.

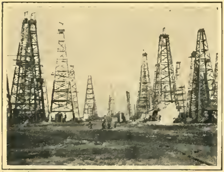
Refining and Testing

About one-fifth of the petroleum produced in the United States is used in the crude form for fuel. Some of it is also used for dressing roads. The rest of the "crude" goes to the refineries.

THE SUCCESSOR TO PETROLEUM
Cliffs of oil shale near Grand Valley, Colorado

Methods of refining vary widely, according to the kind of oil treated and the relative demands for the various finished products. Broadly speaking, there are four main products—gasoline, kerosene, fuel oil and lubricating oil—and a large number of by-products, of which benzine, vaseline, paraffin, road oil, asphalt, and petroleum coke are the best known and most useful.

The crude oil is first heated in a steel or iron still, holding from 600 to 700 barrels of oil. Moderate heating vaporizes the lighter oils contained in the petroleum, and these pass from the top of the still through pipes to the *condensers*, consisting of coils of pipe set in tanks through which water is circulated. Here the oils again assume a liquid form. The temperature of the still is gradually increased, and the various constituents of the crude oil pass to the condensers in the order of their weight, each having a more or less definite vaporizing temperature.*



Courtesy U. S. Geological Survey

OIL DERRICKS ON SPINDLETOP HILL, TEXAS
In this once marvelously prolific oil field the derricks were planted so close together that they almost touched one another

From the condensers pipes termed *running lines* carry the oil to the *tail-house*. Here the stillman watches the passing stream of oil through the glass window of a *look-box*, and occasionally draws samples, which he tests with a hydrometer. He is thus able to determine when the stream is changing from a lighter to a heavier oil, and as soon as this happens he switches the flow of oil leaving the tail-house, by closing one valve and opening another, so that the heavier oil will go to a different tank from the lighter. The first division of the light oils (gasoline, kerosene, etc.) is accomplished in this way, but some of these oils are subsequently re-distilled and further separated, and before they

*This is known as the *intermittent* method of distillation. In the *continuous* method, little practiced in the United States, the oil passes through several stills heated to different temperatures, each still giving off a different product.

are ready for the market they must also be purified and deodorized by chemical treatment and blowing with an air-blast in tall tanks called *agitators*.

The residue left in the crude oil still after the removal of the light oils goes to another still, where it is heated to yet higher temperatures under partial vacuum or by superheated steam, in order to separate the lubricating oils from the paraffin. The latter is subjected to a further process of chilling and pressing, by which it is freed from oil.

Courtesy U S Geological Survey
DISTILLING SHALE OIL IN THE ROCKY MOUNTAINS

Many American refineries, especially in the Western states, produce no lubricating oils, but merely distill the light oils and sell the residue as fuel oils. These are known as "skimming" or "topping" plants, to distinguish them from those which carry out the whole series of operations above described ("lubricating" or "straight-run" plants). A third type of refinery, of more recent origin, employs a process known as *cracking*. This process was formerly used for increasing the yield of kerosene from petroleum, but it is now employed especially in the effort to supply the ever-growing demand for gasoline. It depends upon the fact that the heavy oils, when vaporized, can be split up by pressure and temperature, so as to yield the vapors of light oil, which can then be condensed and treated the same as the products of distillation. The shortage of gasoline has been further relieved by the innovation of compressing this substance from natural gas. (See Monograph No. 5.)

Before petroleum products leave the refinery they are subjected to various tests, to determine whether they are of standard quality and whether their use will be free from danger to the consumer. Both illuminating oils and lubricating oils are likely to give rise to explosions if they contain excessive amounts of the more volatile oils. Accidents of this sort were of frequent occurrence when kerosene was first put on the market, in the middle of the last century, and led to the adoption in all civilized countries of laws prescribing what are called *flash tests* and *fire tests* for such oils. The flash test shows the lowest temperature at which an oil gives off vapor in such quantities as to flash, or burn momentarily, on the approach of a flame or spark. The fire test indicates the lowest temperature at which the oil ignites and continues to burn. A good lamp oil must not only have a safe *flashing-point*, but must be free from acids, which

Courtesy The Texas Company, Tulsa, Okla.
A MODERN LOADING RACK FILLING A TANK TRAIN

would cause the wick to char, and from sulphur, which gives rise to a bad odor in burning. Lubricating oils are tested for flashing-point and for fluidity at various temperatures; fuel oils for their heating value; and so on. All oils are tested for specific gravity (weight in comparison with water), as this is the principal basis of classification of petroleum products. Gravity is expressed on the *Baumé scale*, in which water is rated as 10, and the lightest liquids have the highest values.

CRUDE STILLS AT A TEXAS COMPANY REFINERY

Distributing Refined Oils

The marketing of refined oils furnishes a fine example of the efficiency and economy that may be attained by large-scale business organization. An elaborate system of handling oil in bulk has been built up, not only in this country, but throughout the world. Tank cars and tank steamers carry the oil to a multitude of distributing stations, provided with storage facilities. Local distribution to retail dealers and consumers is effected by means of tank wagons, tank motor-trucks, tank sleighs, and, in countries where man-power is cheap, even by tank push-carts. The advantages of this system are obvious. The customer is relieved of the necessity of buying a container every time he replenishes his supply of oil, and he can buy in such quantities as he desires, rather than in units arbitrarily fixed by the contents of cans or barrels.

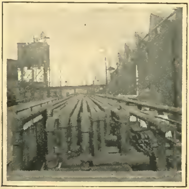
Though by far the greater volume of oil sold in most countries is thus handled in bulk, a large trade has also grown up in packed or "case" oil, in response to the demands of certain markets. Case oil is generally shipped in five-gallon tins, two of which are packed together in a wooden case. In this shape it can be conveniently carried by pack animals and porters in regions where the roads are not good enough for vehicles. In the Far East case oil enjoys special popularity on account of the many uses that are found for the empty tins. In fact, the versatile possibilities of the American oil-tin have become a byword among travelers.

INTERIOR OF PUMP HOUSE AT A TEXAS COMPANY REFINERY

The Future of Petroleum

According to an estimate of the Geological Survey, at the present rate of consumption (1919) the total petroleum resources of the United States will last only about twenty-seven years. Recent sensational developments in foreign fields, such as Mexico

and Persia, encourage the belief that we need not expect a serious shortage of petroleum in the immediate future; but the time will come when this mineral will be too rare and costly for many of the uses to which it is now applied.



PIPE LINE TERMINAL AT BAYONNE, N. J.
These pipes bring oil from Missouri, Ohio, Kansas and Pennsylvania

Various public agencies in this country, including the Bureau of Mines and the Division of Mineral Technology of the National Museum, have pointed out ways in which vast economies may be effected in the use of our waning stock of petroleum. The present methods of pumping oil wells leave a great deal of oil in the ground that might be extracted by the use of compressed air. Methods of drilling permit disastrous incursions of water and the escape of millions of dollars' worth of valuable gas; both of which losses could be prevented by certain rather simple precautions. Losses by fire, leakage and evaporation could be greatly reduced. Above all, there is need of a complete readjustment in the ultimate utilization of petroleum and its products, and it is especially deplorable that so large a proportion of the oil output should be burned in place of coal, instead of being made to yield the many valuable products that can be extracted in the refinery.

Courtesy U. S. Bureau of Mines

A TANK FARM
One tank is burning after being struck by lightning

Of course substitutes will eventually be found for petroleum, and some of these will probably be brought to light through scientific achievements still undreamed of. At present its logical successor appears to be *shale-oil.* This oil has long been distilled on a profitable scale in Scotland, New South Wales and France, and its production has been begun experimentally in our own country, which possesses enormous deposits of oil shales, especially in Utah, Colorado and Wyoming. In fact, it is stated that the amount of oil contained in American shales —still awaiting economical methods of extraction—is vastly greater than our total deposits of petroleum, past and present.

SUPPLEMENTARY READING

THE STORY OF OIL — *By Walter Sheldon Tower*

THE OIL CONQUEST OF THE WORLD — *By Frederick A. Talbot*

PETROLEUM; A RESOURCE INTERPRETATION — *By Chester G. Gilbert and Joseph E. Pogue*
(Bulletin 102, Part 6, U. S. National Museum.)

Standard reference books include Sir Boverton Redwood's "Petroleum and Its Products," and Bacon & Hamor's "American Petroleum Industry."

Many special topics are treated in publications of the U. S. Geological Survey and the U. S. Bureau of Mines.

*** Information concerning the above books may be had on application to the Editor of The Mentor.

THE OPEN LETTER

This is the sixtieth anniversary of the birth of the Age of Oil. In 1859 Edwin L. Drake struck oil for the first time in Titusville, Pennsylvania. The story of Oil is so interesting and so important in its bearing on the life and welfare of mankind that the present anniversary has inspired editorial comment in the public press throughout the country. I cannot do better for the readers of The Mentor than to give them the following reflections from the editorial page of *The New York Sun:*

"Petroleum had been known to the world since the days of Babylon and Nineveh. The Romans burned it in lamps. America had known it since the Franciscan missionary d'Allion saw it floating on springs in Pennsylvania, nearly three centuries ago. It had set the Cumberland River afire thirty years before Bissell's time. Men had tried to burn the crude stuff, skimmed from water, as an illuminant, and while they failed in this they found the oil useful as a lubricant. Others gathered it and sold it as a medicine that would cure all ills.

"It was George H. Bissell who first saw the commercial possibilities of petroleum obtained in huge quantities. As the head of the Pennsylvania Rock Oil Company he leased lands near Titusville, where oil was seen in springs, and then he sent a sample of the oil to Professor Benjamin Silliman for analysis. The distinguished Yale chemist did everything with the sample that the science of that day could apply, and his report so convinced Bissell of the usefulness of refined petroleum that nothing remained, in Bissell's opinion, but to find out whether the earth hid the huge quantities that he suspected lay below the surface.

"Then came the triumph of Drake, a man of 40, who had been clerk, express agent and railroad conductor. Bissell and his associates sent him to Titusville in the spring of 1858 to drill a well. Drake was not a great man, but he was persistent, and it was fortunate for the oil business that this was so. There were no drillers and no tools at Titusville, which was forty miles from the nearest railroad. It took him months to get men and equipment, for he had to drive a hundred miles, after the snow of the first winter had left the roads, to find a driller. Months later, after experiments and accidents, on August 28, 1859, Drake struck oil.

"The sixty years of oil history since 'Drake's Folly' turned out to be America's fortune have been a strange period of business and madness, of honest speculation and plain swindling, of high prices and low, and of great scientific advance. Oil has made huge fortunes for the few and has given wonderful comfort to the millions. It has made possible the automobile, the submarine and the airplane, new types of ships, new methods of warfare, new ways to spend Sunday. It has been a revolutionary force in the grain field and it has put money in the pocket of the roadhouse keeper. Sometimes it has gushed so plentifully that it made itself cheap at times when men did not know the many ways in which it could be used. In 1860, when the yield in Pennsylvania was half a million barrels, the price was as high as $20 a barrel; in 1861, when the yield was quadrupled, the price fell to 49 cents a barrel on the average, and there were days when the price was 10 cents.

"If Drake were alive to-day he would be an astonished centenarian, for the oil fury now is even greater than that which followed his strike at Titusville—and his days were those when men left their old jobs and staked everything on hitting a gusher or a free pumping well. He would be surprised to see how small his old field is now as compared with the production in the West and Southwest. And he, as a practical man who knew that the sure way to wealth in oil was to take the mineral from the ground and sell it, would shudder at the folly of the millions who, without ever having seen a well, are pouring their hard earned money into companies which drill nothing but the investor's pocket."

W. D. Moffat
EDITOR

COURTESY CURRIER & CO., KANSAS CITY

DRILLING FOR OIL IN OKLAHOMA

THE merits of petroleum and other natural bitumens were appreciated in remote antiquity. The ancient Chinese and Japanese used natural gas for heating and lighting. Mineral tar (maltha) was used as a cement in constructing the walls of Babylon and Nineveh. It is the "slime" mentioned in the Biblical story of the Tower of Babel. The Egyptians used bitumen in embalming their mummies. The liquid bitumen to which we now especially apply the name "petroleum," and which in old writings is often described as "naphtha," was also well known to the ancients. Herodotus describes the process of collecting oil from the pits of Ardericca, near Babylon, and there are Roman accounts of the wells near Agrigentum, in Sicily, the oil from which was burned in lamps in the temple of Jupiter. The Chinese and Japanese dug oil wells in the early centuries of the Christian era, some of which, it is said, were 900 feet deep. Sir Boverton Redwood tells us that long before our era the Chinese drilled wells for natural gas, using appliances very much like those now used in well-drilling. A rude method of drilling for oil has been practiced for centuries in Burma. In the Baku region, on the shore of the Caspian Sea, where burning jets of natural gas excited superstitious interest in very ancient times, a thriving oil industry —the forerunner of the far greater one that now flourishes in the same region—existed in the thirteenth century A. D., as we learn from the descriptions of Marco Polo.

All these early undertakings, however, were quite insignificant in comparison with the vast petroleum industry of today, which may be said to date from August, 1859, when oil was struck on Oil Creek, Pennsylvania, hy "Colonel" Edwin L. Drake, an ex-railway conductor from New England. Drake had been engaged hy a New Haven company to seek for oil, and he, in turn, secured the services of "Old Billy" Smith and his sons, who had gained practical experience in the drilling of salt wells. It had been the practice, in sinking such wells, to dig an open pit down to bedrock, and then begin work with the drilling tools. Drake tried this plan, hut his efforts were baffled by the continual caving of the soft sand. He then hit upon the idea of driving an iron pipe down to the rock and operating the drill through the pipe. This expedient proved entirely successful. The pipe was sunk more than fifty feet, and drilling had only progressed to about sixty-nine feet—a very moderate depth for an oil well—when petroleum began to flow from the mouth of the bore-hole. The well yielded about twenty barrels a day for a year or so, and was then destroyed by an explosion.

There was nothing particularly novel in Drake's achievement, for it was merely an application of the well-known principle of the artesian well to the extraction of oil. Many such wells had been sunk in this country to secure hrine for salt-making, and some of these had yielded large quantities of petroleum at a time when the virtues of this substance were not fully recognized. The reason why the drilling of Drake's well ushered in a new epoch was that it furnished the means of supplying a demand that had recently arisen for petroleum, in consequence of the invention of methods by which it could be refined for use as an illuminant.

The region about Oil Creek at once became the scene of a great oil "boom," which, while it hrought wealth to many, was disastrous to Drake and his associates. In leasing the site of their well they had agreed to pay a royalty of twelve cents a gallon for all oil extracted. As soon as oil production in the neighborhood began on a large scale, the market price fell to such an extent that they could make no money. The company was dissolved, and Drake himself endured many years of extreme poverty, until some of the men who had profited hy his discovery raised a fund for his relief and the state of Pennsylvania granted him an annuity.

A "Drake Memorial Museum" now stands in the town of Titusville, Pa., near the place where he drilled his well, and a magnificent monument has been erected in the local cemetery to the man who is described in the inscription as the "founder of the petroleum industry."

WRITTEN FOR THE MENTOR BY C. F. TALMAN
ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189

COURTESY DIVISION OF MINERAL TECHNOLOGY, U. S. NATIONAL MUSEUM

MODEL OF A PETROLEUM REFINERY, U. S. NATIONAL MUSEUM

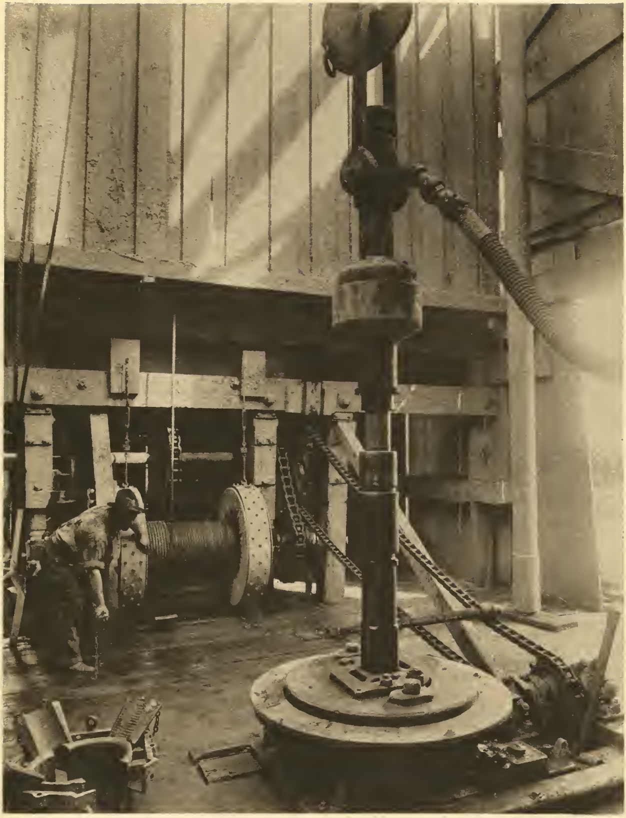
IN 1859 the United States produced only 2,000 barrels of oil. Two years later the production was over 2,000,000 barrels. The 100,000,000 mark was passed in 1903. In 1917, under the stimulus of the demand created by the war in Europe, the output rose to more than 348,000,000 barrels. From 1859 to 1876 practically all the oil produced in this country came from Pennsylvania. In the latter year Ohio, California and West Virginia entered the field. At present Oklahoma and California are rivals for first rank among the oil-producing states, while in second order come Texas, Illinois and Louisiana. The history of the various oil-fields is a series of sensational events. At frequent intervals a great "strike" is made—often where it is least expected—and a new oil "pool" rivets the attention of operators and investors. The Texas oil boom of 1901 rivaled that of the early days in Pennsylvania. The center of excitement was a little area of about 300 acres, known as Spindletop, which in four years produced more than 30,000,000 barrels of oil. There was the usual frenzied speculation, and the usual crop of disappointed investors. Many other productive fields have since been developed in Texas, but the glory of Spindletop has departed.

The oil-producing regions of the United States are grouped in certain large areas, each of which yields a more or less distinct type of oil. In the east we have the Appalachian field, the oils from which give by ordinary refining methods the highest percentage of gasoline and kerosene, and are free from asphalt and sulphur. The Lima-Indiana field, which includes northwestern Ohio, yields an oil which is so much contaminated with ill-smelling sulphur that it could not be used for making kerosene until special methods of distillation had been invented. The Illinois field produces oils varying a good deal in their distillation products, and containing both paraffin and asphalt. The great Mid-Continent field, now the most productive in the country, yields oils varying even more widely than those of Illinois. Oils from the Gulf field are characterized by a relatively high percentage of asphalt and low percentages of the lighter products (gasoline, kerosene, etc.). The oils of the Rocky Mountain field are mainly of paraffin base, and suitable for ordinary refining. The California oils contain much asphalt and little or no paraffin. They are especially important as a source of fuel oils, but also yield lamp oil, lubricants and oil asphalt.

California is the scene of the unique enterprise of extracting oil from wells sunk in the bed of the sea. These wells are situated at Summerland, near Santa Barbara, and are still among the "sights" of the coast, though few of them are now producing oil. The Summerland oil field was opened in 1891, and within four years more than 300 wells had been drilled. Some of these wells are in places where the water is twenty-five feet deep at low tide, and their depth is from 300 to 1,200 feet. The wells are sunk from light piers extending out from the shore.

The productive oil wells drilled in the United States in the year 1916 numbered 18,777. The total number in operation is about 225,000.

WRITTEN FOR THE MENTOR BY C. F. TALMAN
ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189



COURTESY OIL WELL SUPPLY CO., PITTSBURGH

DRILLING AN OIL WELL BY THE ROTARY PROCESS

THE medicinal virtues of petroleum were recognized in America long before its other useful qualities were even suspected. The white settlers acquired from the Indians the habit of using it as a medicine, and it was in this character that it achieved prominence in the eighteenth century under the name of "Seneca oil." A description of the occurrence of oil in New York was published by a French missionary in 1632.

During the first half of the nineteenth century petroleum acquired a bad reputation as a source of trouble in the drilling of brine wells. This ill-smelling oil, then supposed to be of little or no value, often poured forth in such quantities as to ruin the brine. On Little Rennox Creek, near Burkesville, Ky., a brine well drilled in 1829 yielded so much oil that the neighboring Cumberland River was covered with it. Eventually the floating oil caught fire and burned for a distance of fifty-six miles. Most of the oil from this veritable "gusher" was wasted, though some of it was bottled and sold as "American Medicinal Oil" in the United States and Europe.

A method of distilling an illuminating oil from petroleum invented by James Young, in Scotland; a scientific investigation of American oil by Prof. Benjamin Silliman, of Yale University; and the introduction of an improved burner for lamps by Samuel Kier, a Pittsburgh druggist, all paved the way for a new era in the use of petroleum. Moreover, the distillation of an illuminating oil from coal, under the name of "Kerosene," according to a process introduced by Abraham Gesner, had been carried on extensively in the United States for some years before the drilling of Drake's pioneer oil well, and it was a comparatively easy matter to adapt the plants engaged in this industry to the more lucrative business of refining petroleum.

As mentioned in the preceding monograph, a great oil "boom" began in Pennsylvania in 1859. A horde of prospectors flocked to the Oil Creek region, and the excitement that prevailed paralleled that attending the gold discoveries in California ten years earlier. Oil derricks and board shanties soon dotted the once placid countryside. Among the many towns that sprang into bustling life was Pithole City, which in six months acquired a population of from 10,000 to 15,000 people and boasted miles of streets, lined with business blocks, churches and pretentious hotels. Today this mushroom city, together with many others that arose at the same time, has vanished from the map of Pennsylvania.

The speculative frenzy of the "Pennsylvania Oil Bubble" reached its height in the middle sixties, at which period no fewer than 1,000 oil companies had been launched, with a nominal capital aggregating about $600,000,000, and an actual paid-in investment of $100,000,000. The bubble burst in 1865, in consequence of the failure of the Pithole wells and a series of destructive floods and fires. Soon afterward, however, the industry was re-established on a sane basis, and the district in which Drake drilled his epoch-making well is still an important contributor to the oil supply of the country.

WRITTEN FOR THE MENTOR BY C. F. TALMAN
ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189

COURTESY U. S. BUREAU OF MINES

A 55,000-BARREL OIL TANK ON FIRE

THE most dreaded enemy of the oil man is fire. The gas hanging about the well or enveloping the top of a tank is set aflame on very slight provocation, and the fire spreads instantly to the oil. It may be a stroke of lightning, or a match thrown carelessly upon the ground, or a spark struck from a stone that starts the trouble.

Even the headlight of a passing automobile has been known to start an oil fire. Once going, the fire not only burns with a fury comparable to that of a volcano in eruption, but is likely to spread far and wide, as everything in the neighborhood of an oil-well is saturated with oil. Pouring water on an oil fire merely makes matters worse, as the water gathering on the ground carries the flaming oil to a distance. Live steam is the most effective means of smothering the flames. Certain chemicals, such as sodium bicarbonate and sulphuric acid, are sometimes used with success, and another plan is to dig a tunnel which taps the well underground and thus cuts off the fuel from the flame.

A great "gusher" on fire is an awe-inspiring spectacle. Tremendous fires of this kind have often raged in the Russian oil-fields, but the biggest of all oil fires was that which occurred in 1908 at the "Dos Bocas" well in Mexico. A gigantic "gusher" had been struck, smashing the derrick to fragments, bursting the casing of the well, and causing a miniature earthquake as the torrent of oil strove to find vent through the narrow bore-hole. Although the fires under the boilers were promptly drawn and drenched with water, some remaining embers set fire to the gas and oil, and the column of flame shot to a height of 1,500 feet. By night this fountain of fire was visible 200 miles out at sea. The Dos Bocas well burned for fifty-eight days, during which time it is estimated that 2,000,000,000 gallons of oil, worth $25,000,000, was consumed. Many ingenious plans for extinguishing the fire were tried in vain, and it finally died a natural death, owing to the exhaustion of the oil and the choking of the well with earth and débris.

Oil fires are estimated to cause a loss of 1,500,000 barrels of oil in the United States each year, on an average. Some years ago fire broke out in the midst of the famous Spindletop oil field, in Texas, where more than 200 closely crowded wells had been drilled. A district ten acres in extent was completely devastated, and the rest of the field was saved only by throwing up an earthen wall around the doomed area. In 1916 a disastrous fire occurred in the Cushing field, in Oklahoma. More than a hundred derricks, scores of homes and pump houses, and other structures were destroyed, entailing a loss of $2,000,000 in a very short time.

The work of putting out fires in oil wells and gas wells has become a regular profession, and there are many men who make a business of undertaking such tasks. The professional fire fighter often receives a lump sum of $5,000 or more, and his expenses, for putting out a fire.

A burning oil tank presents a less difficult problem to deal with than a burning well, because all that can be done is to let the fire burn itself out and prevent it from spreading. Such fires are frequently started by lightning. A common expedient of the fire fighter is to puncture the bottom of a burning tank with the aid of a small cannon, allowing the oil to run out into a pond which has been laid out around the tank in preparation for just such an emergency. The fire thus has a large surface to burn over, and soon dies out. Tank "farms," or groups of large storage tanks, are generally provided with a network of high-pressure water and steam pipes, with plugs for the connection of hoses at intervals, and the tanks themselves are equipped with sprinklers, which pour water down the outside of the tank to keep it cool during the fire, while from sprinklers inside the tank jets of steam are played on the flames. At the same time the oil is rapidly drawn from the burning tank into others, and thus the fire is generally soon brought under control.

WRITTEN FOR THE MENTOR BY C. F. TALMAN

ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189

COURTESY OIL WELL SUPPLY CO., PITTSBURGH

GAS WELL "BLOWING WILD"

THERE are many places in the world at which gas, formed along with petroleum deep in the earth, issues naturally from the ground. Jets of such gas, when ignited, furnish the so-called "perpetual fires" which have been an object of religious reverence from remote times. Those burning near Baku, on the western shore of the Caspian Sea, long attracted pilgrims from Persia and India. Natural gas was also put to practical use in ancient times in China and Persia.

In the United States gas piped from a well at Fredonia, N. Y., was used for illuminating purposes as early as 1821, but many years passed before the possibilities of this natural resource were appreciated. In fact, in the early days of the oil industry the large deposits of gas that were sometimes tapped in drilling oil-wells were regarded merely as a nuisance; the gas was piped to a safe distance from the well and burned, for the sake of getting rid of it. Even at the present day an enormous amount of gas is thus wasted at oil-wells. The use of natural gas on a large scale did not begin in this country until the early eighties of the last century. It is now obtained commercially in twenty-three states, the largest yields being furnished by West Virginia, Pennsylvania, Ohio and Oklahoma.

Gas-wells are drilled in the same manner as oil-wells. Unlike oil, however, gas cannot be stored indefinitely in tanks, but must be piped directly to centers of consumption. The gas issues from a new well under high pressure, but this soon declines, so that it is necessary to locate pumping stations (properly called "compressors") at various points along the line in order to carry the gas to its destination. Natural gas is not only a cheap and valuable fuel and illuminant for domestic use, but also an ideal fuel for many industrial purposes. It is used on a very extensive scale in blast furnaces, foundries, rolling mills, glass and pottery furnaces and cement kilns. The consumption of natural gas in this country is about three and a half as great as that of artificial city gas.

In recent years a highly volatile variety of gasoline has been extracted from natural gas by certain processes of compression and absorption. This natural-gas gasoline, or "casing-head" gasoline, is generally blended with petroleum distillates which are too heavy to be marketed alone as gasoline. About one-tenth of the gasoline now produced in the country is obtained in this manner, helping materially to relieve the shortage of motor-fuel—though only temporarily, since the supply of natural gas underground is limited.

One of the most interesting uses of natural gas was developed during the world war. The gas produced in Kansas, Oklahoma and Texas contains a considerable admixture—one or two per cent.—of an extremely light chemical element known as helium. Methods were devised for extracting this substance in large quantities and it was used for filling airships and balloons in place of hydrogen. Helium has the great advantage over hydrogen, especially in time of war, that it is non-inflammable and non-explosive.

Gas wells sometimes indulge in spectacular exhibitions, vying with those of oil-wells. The original pressure may be so great that the well "blows wild" for some time before it can be capped and brought under control. Great fires also occur at the gas-wells. The "Maggie Vanderpool" well, near Caney, Kansas, was fired by a flash of lightning on February 19, 1906. A sheet of flame 225 feet high illuminated the country for miles around, and during the five weeks that elapsed before the fire was extinguished more than $25,000,000 worth of gas was consumed. It is said that, although exceptionally cold winter weather prevailed at the time, the heat from the burning well caused the shrubs in the vicinity to burst into leaf and the prairie flowers to blossom.

WRITTEN FOR THE MENTOR BY C. F. TALMAN
ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189

COURTESY BARBER ASPHALT PAVING CO., PHILADELPHIA

DIGGING ASPHALT FROM THE TRINIDAD ASPHALT LAKE (BRITISH WEST INDIES)

IT is a fortunate coincidence that while one product of petroleum (gasoline) is responsible for a ruinous amount of wear and tear on roads that were good enough for the slow-going traffic of the past, another (asphalt) furnishes a road making material that will resist almost any amount of hard usage. When certain kinds of petroleum are subjected to heating, at a sufficiently high temperature, or to prolonged evaporation, all the lighter constituents pass off as gas, and a thick pitch-like substance remains. This is asphalt. Heated with sulphur, it becomes a brittle solid. Liquid and solid asphalts are thus made as a by-product in the process of refining asphaltic petroleum, and sold as "artificial asphalts"; while Nature carries out similar processes underground, giving us liquid and solid varieties of "natural asphalt."

Natural asphalts are obtained on a commercial scale in the western United States, but their most important sources are tbe so-called "pitch lakes" of Trinidad and Bermudez. Trinidad is an island of the British West Indies, close to the coast of South America, while the Bermudez deposit is on the adjacent mainland, in Venezuela.

The Trinidad "lake," about 114 acres in extent, is so hard and solid that it bears the weight of a narrow-gauge railway, and the asphalt is dug out in large lumps with a mattock. The process has been thus described by a recent writer:

"The gang of barefooted workmen in one place may number thirty men, of whom half a dozen will do the digging. They will work on a space perhaps sixty feet long and forty feet wide, and in the course of the day they will dig down to a depth of three feet, or more in some places. Go to that same spot the next morning and you will find it a little rough but approximately level with the rest of the lake. The hole has been filled up, and in the course of a week all traces of the digging will be obliterated. This does not mean that fresh asphalt has come into the lake from underground sources. On the contrary, it must be that excavations are filled by a very slow settling or leveling of the surface asphalt. The digging done in the past years has caused the general level of the lake to sink several feet."

Borings show that the asphalt extends to a depth of at least 135 feet, and the total deposit must amount to many millions of tons. The Bermudez lake is of larger area but quite shallow, and the asphalt, except for a thin surface crust, is much softer than Trinidad asphalt.

In Europe there are extensive deposits of limestone impregnated with asphalt, and the asphalt pavements of European cities have generally been made with this asphaltic limestone, or "rock asphalt." American asphalt pavements consist of sand and pulverized limestone, held together with an asphaltic cement, laid upon a concrete foundation. Asphalt blocks, made of crushed stone and asphalt pressed into forms by briquetting machinery, are also used for paving.

Asphalt is used for many purposes besides paving. Felt, impregnated with asphalt, is a common material for roofing, and is superior to simple coal-tar felting, as it does not become brittle under the influence of heat or with age. Pure varieties of natural asphalt are melted into oils to form a black, lustrous varnish, widely used for the protection of water-tanks, piping, etc. Owing to its remarkable adhesive properties, asphalt is used in making waterproof cements and mortars.

WRITTEN FOR THE MENTOR BY C. F. TALMAN
ILLUSTRATION FOR THE MENTOR, VOL. 7, No. 17, SERIAL No. 189

THE COMING OF OIL

WHILE the nineteenth century will be known to history as the Coal Age, the twentieth century certainly will go down to posterity as the Oil Era. Oil is becoming more and more indispensable to our complex social and industrial existence; in fact, it is almost impossible to mention a phase of human activity in which it does not play a more or less prominent part in one form or another.

❖ ❖ ❖

At the same time, however, it must not be thought that oil and its uses constitute a modern discovery. Far from it. Oil was used for lighting and heating, if not for power, long before the fuel value of coal was recognized. The earliest civilization employed it, in an asphaltic form, as a cement in their building operations. Two thousand years ago the citizens of Agrigentum, in Sicily, used oil as an illuminant, burning it in crudely fashioned lamps. And does not the Parable of the Virgins indicate that oil was an acknowledged source of light at the dawn of the Christian era? In some countries, where it oozes from the ground in the form of natural springs, the aborigines have regarded it with reverential awe since time immemorial. Pilgrimages were made to the oil-fires of Baku for centuries. The Red Men, long before the white man's invasion of North America, placed implicit faith in the properties of "Seneca" oil. The tribes were wont to gather at the oil-springs, where the medicine man ministered oil treatment, for illness and disease, and the braves apparently entertained high opinions concerning the therapeutic properties of this substance. Under these circumstances the present movement may be characterized rather as a revival, forced upon civilization today by economic considerations.

❖ ❖ ❖

One would not be far wrong if one expressed the opinion that the community today eats, drinks and sleeps—in fact, exists—upon petroleum. The fact that a round two hundred articles are obtained from this liquid mineral conveys a vivid impression of the varied requirements which the nauseating, unprepossessing raw material is made to fulfil, and also of the immense demand that is made upon the chemist to fit the products for such an array of applications. It emphasizes the extreme dependence which the world at large is forced to place upon oil today. Mankind cannot possibly get along without it. It is the most useful and ubiquitous servant that ever has been revealed. It was not so many years ago that coal was regarded as indispensable to our existence. This situation prevails no longer. The world could roll along very comfortably without coal. But if the oil resources of the world were extinguished, the whole advance of civilization would come to a dead stop. Every mechanical device would be condemned to idleness; machinery cannot move without oil any more than the human frame can subsist without water. The unique value and indispensability of oil lies in the fact that, not only can it be made to fulfil every purpose for which coal at present is employed, but can be utilized for a host of other applications as well.

From "The Oil Conquest of the World," by F. A. Talbot.

THE MENTOR

THE WEALTH OF THE MENTOR

1 Beautiful Children in Art, by Gustav Kobbé
2 Makers of American Poetry, by Hamilton Mabie.
3 Washington the Capital, by Dwight Elmendorf.
4 Beautiful Women in Art, by J. T. Willing
5 Romantic Ireland, by Elmendorf
6 Masters of Music, by W J Henderson
7 Natural Wonders of America, by Elmendorf.
8 Pictures We Love to Live With, by Jas. Huneker.
9 The Conquest of the Peaks, by Chas E. Fay.
10 Scotland, the Land of Song and Scenery, by Elmendorf.
11 Cherubs in Art, by Kobbé.
12 Statues with a Story, by Lorado Taft.
13 The Discoverers, by Albert Bushnell Hart
14 London, by Elmendorf.
15 The Story of Panama, by Stephen Bonsal.
16 American Birds of Beauty, by E H Forbush.
17 Dutch Masterpieces, by John C. Van Dyke.
18 Paris, the Incomparable, by Elmendorf.
19 Flowers of Decoration, by H. S Adams
20 Makers of American Humor, by Burges Johnson
21 American Sea Painters, by Arthur Hoeber.
22 The Explorers, by Albert Bushnell Hart
23 Sporting Vacations, by Dan Beard.
24 Switzerland, the Land of Scenic Splendors, by Elmendorf.
25 American Novelists, by Hamilton Mabie.
26 American Landscape Painters, by Samuel Isham
27 Venice, the Island City, by Elmendorf.
28 The Wife in Art, by Kobbé.
29 Great American Inventors, by H. Addington Bruce.
30 Furniture and Its Makers, by C. R. Richards.
31 Spain and Gibraltar, by Elmendorf.
32 Historic Spots of America, by R M. McElroy.
33 Beautiful Buildings of the World, by C Ward.
34 Game Birds of America, by E H. Forbush
35 The Contest for North America, by A. B Hart.
36 Famous American Sculptors, by Lorado Taft.
37 The Conquest of the Poles, by Rear Admiral Peary
38 Napoleon, by Ida M Tarbell.
39 The Mediterranean, by Elmendorf.
40 Angels in Art, by Van Dyke.
41 Famous Composers, by Henry T. Finck
42 Egypt, the Land of Mystery, by Elmendorf.
43 The Revolution, by Albert Bushnell Hart.
44 Famous English Poets, by Mabie
45 Makers of American Art, by J. T. Willing.
46 The Ruins of Rome, by Botsford.
47 Makers of Modern Opera, by H. E. Krehbiel.
48 Durer and Holbein, by F. J Mather, Jr.
49 Vienna, the Queen City, by Elmendorf.
50 Ancient Athens, by Botsford.
51 The Barbizon School, by Hoeber.
52 Abraham Lincoln, by Albert Bushnell Hart.
53 George Washington, by McElroy.
54 Mexico, by Frederick Palmer.
55 Famous American Women Painters, by Arthur Hoeber
56 The Conquest of the Air, by Henry Woodhouse.
57 Court Painters of France, by Wm.A.Coffin, N.A.
58 Holland, by Elmendorf.
59 Our Feathered Friends, by E. H Forbush.
60 Glacier National Park, by Hornaday.
61 Michelangelo, by Kenyon Cox.
62 American Colonial Furniture, by Esther Singleton.
63 American Wild Flowers, by Walter P. Eaton.
64 Gothic Architecture, by Ward.
65 The Story of the Rhine, by Elmendorf.
66 Shakespeare, by Mabie
67 American Mural Painters, by Hoeber.
68 Celebrated Animal Characters, by Hornaday.
69 Japan, by Elmendorf.
70 The Story of the French Revolution, by Hart
71 Rugs and Rug Making, by John K Mumford.
72 Alaska, by Belmore Browne
73 Charles Dickens, by Mabie.
74 Grecian Masterpieces, by Lorado Taft.
75 Fathers of the Constitution, by Albert Bushnell Hart
76 Masters of the Piano, by Finck.
77 American Historic Homes, by Singleton.
78 Beauty Spots of India, by Elmendorf
79 Etchers and Etching, by Frank Weitenkampf.
80 Oliver Cromwell, by Albert Bushnell Hart.
81 China, by Elmendorf.
82 Favorite Trees, by Hornaday
83 Yellowstone National Park, by Elmendorf.
84 Famous Woman Writers of England, by Mabie.
85 Painters of Western Life, by Hoeber.
86 China and Pottery of Our Forefathers, by Esther Singleton.
87 The Story of The American Railroad, by Albert Bushnell Hart.
88 Butterflies, by W. J. Holland.
89 The Philippine Islands, by Dean C. Worcester.
90 Great Galleries of the World—the Louvre, by Van Dyke.
91 William M Thackeray, by Mabie
92 The Grand Canyon, by Elmendorf.
93 Architecture in American Country Homes, by Aymar Embury.
94 The Story of the Danube, by A. B. Hart.
95 Animals in Art, by Kobbé.
96 The Holy Land, by Elmendorf.
97 John Milton, by Mabie.
98 Joan of Arc, by Ida M. Tarbell.
99 Furniture of the Revolutionary Period, by Esther Singleton.
100 The Ring of the Nibelung, by Finck
101 The Golden Age of Greece, by Botsford.
102 Chinese Rugs, by Mumford.
103 The War of 1812, by Albert Bushnell Hart.
104 Great Galleries of the World—The National Gallery, London, by Van Dyke.
105 Masters of the Violin by Finck.
106 American Pioneer Prose Writers, by Mabie.
107 Old Silver, by Esther Singleton.
108 Shakespeare's Country, by William Winter.
109 Historic Gardens of New England, by Mary H Northend.
110 The Weather, by C. F Talman.
111 American Poets of the Soil, by Johnson.
112 Argentina, by Newman.
113 Game Animals of America, by Hornaday.
114 Raphael, by Van Dyke
115 Walter Scott, by Mabie.
116 The Yosemite Valley, by Elmendorf.
117 John Paul Jones, by Albert Bushnell Hart.
118 Russian Music, by Henry T Finck.
119 Chile, by E M. Newman.
120 Rembrandt, by John C. Van Dyke.
121 Southern California, by C P. Lommis
122 Keeping Time, by C. F. Talman.
123 American Miniature Painting, by Mrs. Elizabeth Lounsbery.
124 Gems, by Esther Singleton.
125 The Orchestra, by W J. Henderson.
126 Brazil, by E. M. Newman.
127 The American Triumvirate, by A. B. Hart.
128 The Madonna and Child in Art, by Van Dyke.
129 The Story of the American Navy, by Barnes.
130 Lace and Lace Making, by Esther Singleton.
131 American Water Color Painters, by Kobbé.
132 Peru, by E. M Newman.
133 The Story of the American Army, by A. B Hart.
134 Our Planet Neighbors, by Harold Jacoby.
135 The Story of Russia, by Leo Pasvolsky.
136 The Story of the Hudson, by A. B. Hart.
137 Prehistoric Animal Life by Dr. Matthew.
138 Hawaii, by E. M. Newman.
139 Earthquakes and Volcanoes, by C. F. Talman.
140 The Canadian Rockies, by Ruth Kedzie Wood.
141 Corot, by Elliott Daingerfield.
142 Bolivia, by E. M Newman.
143 Russian Art, by William A. Coffin.
144 The American Government, by A. B. Hart.
145 Christmas in Picture and Story, by Singleton.
146 The Picture on the Wall, by Weitenkampf.
147 Lafayette, by Albert Bushnell Hart.
148 American Composers, by Henry T. Finck.
149 The Luxembourg Gallery, by Wm. A Coffin.
150 Julius Caesar, by Prof. George W. Botsford.
151 The Incas, by Osgood Hardy.
152 Rodin, by Emile Villemin.
153 The Columbia River, by Ruth Kedzie Wood.
154 The Story of Coal, by C. F. Talman.
155 Benjamin Franklin, by A B Hart.
156 The Forest, by Henry S. Graves.
157 Metropolitan Museum of Art, by S. P. Noe.
158 The Cradle of Liberty, by A B. Hart.
159 Mt. Rainier National Park, by Browne.
160 Photography, by Paul L Anderson.
161 Virgin Islands, by E. M. Newman
162 Makers of Modern American Fiction (Men), by A. B Maurice.
163 Mississippi River, by A. B Hart.
164 Our Friend the Dog, by Walter A. Dyer.
165 Reclaiming the Desert, by C J. Blanchard.
166 Georges Guynemer, by Howard W. Cook.
167 France in War Time, by E M Newman.
168 Chinese Art, by Mrs F. Ayscough.
169 King Arthur and the Round Table, by F L Pyne.
170 Calendars and Almanacs, by C. F Talman.
171 Italy Under War Conditions, by E M. Newman
172 Women Sculptors of America, by Lorado Taft.
173 England Under War Conditions, by E. M. Newman.
174 Masters of French Music, by W. J. Henderson.
175 Story of Iron and Steel, by C. F. Talman.
176 American Poets of Today (Men) by Howard W. Cook.
177 Glass and Glassmaking, by Esther Singleton.
178 Lewis and Clark Expedition, by R. K. Wood.
179 Aerial Navigation, by Ladislas d'Orcy
180 Story of Versailles, by Francis Loring Pyne.
181 American Naturalists, by Ernest Ingersoll.
182 Spanish Art, by W. D Starkweather
183 The Story of Uncle Sam, by A. B. Hart.
184 The Honey Bee, by Frank C. Pellett.
185 Makers of Modern American Fiction (Women), by Arthur B Maurice
186 The Story of the Lens, by F L Darrow.
187 The St Lawrence River, by Ruth K Wood.
188 Citizens of the Jungle, by W T Hornaday

Price 20 Cents Each. Order the copies you want by post card and we will send them, all charges paid, and mail you a bill.

THE MENTOR ASSOCIATION, 114-116 East 16th Street, New York City

MAKE THE SPARE MOMENT COUNT


OPEN EVENINGS AND SUNDAY MORNINGS
OPEN EVENINGS AND SUNDAY MORNINGS
KODAK DEVELOPING 10¢ THE ROLL PRINTS 3¢ UP
PHOTOS
DREGS
CHAMBERS DRUG CO.
DRUG CO
THEATRICAL MAKE UP
LA BARA
SECURITY